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DEVELOPING INTELLIGENTLY INTERACTIVE COMPUTERIZED WARGAMES

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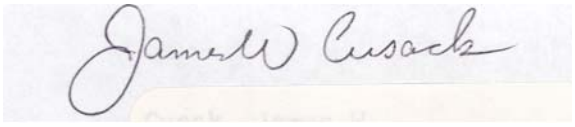
FOR THE DIRECTOR: 

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13. ABSTRACT ***(Maximum 200 Words)***

The commercial computer game industry has recently made giant technological leaps. These advances have not been used to their full potential. Many of today's computer games have better graphics, sound and interfaces than the most advanced military simulations, and are much less expensive. However, most games in the commercial sector fall short when it comes to artificial intelligence (AI). People are beginning to demand improved AI, and for good reason. Once you have determined the behavior of the computer forces, the game ceases to be challenging. It would be beneficial to the military to harness the power of commercial games' outstanding graphics and intuitive interfaces, and integrate an advanced AI into such a game. This project focuses on the genre of games known as strategy games or war games. They are command and control (C2) oriented games where the user commands a group of forces, competing against enemy forces. We evaluated fifteen commercial games of this genre to attempt to determine the feasibility of incorporating an advanced AI into one or more of them. We propose that government experts in AI and/or C2 work with commercial game developers to create compelling, advanced simulations for use in military Planning and training.

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Developing Intelligently Interactive Computerized Wargames

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Abstract

The commercial computer game industry has made giant technological leaps in the past few years. These advances have been greatly enjoyed by the general public, yet they have not been used to their full potential. Many of today's computer games have better graphics, sound and interfaces than the most advanced military simulations, and are much less expensive. However, most games in the commercial sector fall short when it comes to artificial intelligence (AI). Until very recently, AI was never a part of the game that a developer would spend time on, because it was the graphics and fun factor that sold games, not great AI. People are beginning to demand improved AI, and for good reason. Once a player has determined the behavior of the computer forces, the game becomes easy to beat. The player can defeat the computer the same way every time, so the game ceases to provide a challenge.

It would be beneficial to the military if we could harness the power of the commercial games' outstanding graphics and intuitive interfaces, and integrate an advanced AI into such a game, so that it could be used for training. This project focuses on the genre of games known as strategy games or war games. They are command and control (C2) oriented games where the user commands a group of forces, leading them against enemy forces. We evaluated fifteen commercial games of this genre to attempt to determine the feasibility of incorporating an advanced AI into one or more of them. We found that some had editing tools, but none gave us the flexibility we would need to improve the AI. The only way to change the AI would be to change the source code, which we did not have access to. We propose that government experts in AI and/or C2 get together with commercial game developers to create compelling, advanced simulations for use in planning and training in the military.

Introduction

The main objective of this project was to attempt to replace the traditional AI in a commercial computerized war simulation with a non rule-based, intelligently interactive AI engine. This new AI would allow personnel interested in developing command and control skills to train against a computer adversary that behaves like a human adversary. This would be beneficial because rule-based computer opponents become predictable once the human learns the game. This approach also has advantages over the "humans

versus humans" approach because it requires less manpower, and it can be calibrated (the operator has control over how difficult the computer opponent is to defeat).

In order to make progress towards this objective, the following approach was used. We became familiar with many commercially available wargames in which command and control is the emphasis. We then attempted to determine which one(s) had the greatest potential to be used as training programs for military commanders, pilots, tank drivers, and/or other applicable military fields. A wargame's potential for training was measured by attributes such as its user interface, its complexity, its representation of the elements of combat, and perhaps most importantly, its mutability. We wanted to make alterations to the games, with the purpose of increasing their applicability to military training purposes.

In the past few years, the commercial wargaming industry has made significant improvements in networked gaming capabilities. The reason is that people become uninterested in playing against computer intelligence after some time, because of its predictable nature. Networked gaming is the industry's answer to this problem. The same problem exists in military training platforms, resulting in the trainee learning to beat a game, but not necessarily a thinking, unpredictable human adversary. In order for a person to learn how to defeat another person, he or she must either train in opposition to another person, or train against a computer opponent that is basically indistinguishable from a human adversary. Integrating a non rule-based artificial intelligence into existing command and control wargames to act as a learning, unpredictable adversary to the trainee could potentially help people learn to beat humans without ever playing against another human. The advanced AI could be developed using tools such as neural networks and evolutionary computation. Since the artificial intelligence would not be rule based, it would be difficult for the human trainee to predict the computer's next move. This would result in a much more realistic simulation, in which the trainee would not learn how to beat a game, but instead would learn to defeat a reactive, subtle enemy similar to the commander they would face in a real war. Other important results of this project may include learning new concepts and methods of visualization, better ways of presenting information to military commanders, and new command and control mechanisms.

A potential customer that may be interested in wargames for training purposes is Air Education and Training Command (AETC). They list a deficiency in Wargaming and Simulation. The work proposed above has the goal of advancing the current quality of wargaming for training purposes, which would help in eliminating the deficiency perceived by AETC.

Background

This section is intended to provide information about the history of computer wargaming, and will focus particularly on commercial games. An excellent article by John E. Laird and Michael van Lent(1) details the most interesting aspects of this topic.

> Given that our personal goal is to build human-level AI systems, we have struggled to find the right application for our research that requires the breadth and depth of human-level intelligence. In 1991, we found a start in computer generated forces for large-scale distributed simulations. Effective military training requires a complete battle space with tens if not hundreds or thousands of participants. The real world is too expensive and dangerous to use for continual training, and even simulation is prohibitively expensive

> and cumbersome when fully manned with humans. The training of four pilots to fly an attack mission can require over twenty planes plus air controllers. The military doesn't even have a facility with twenty manned simulators, and if it did, the cost in personnel time for the other pilots and support personnel to train those four pilots would be astronomical.

The point of the above section is that computer simulations are beneficial for developing AI systems for financial reasons. However, even simulations can be very costly to develop. Laird and van Lent explain:

> Although computer generated forces are a good starting application for developing human-level AI, there are extremely high costs for AI researchers to participate in this work. It requires a substantial investment in time and money to work with the simulation environments and to learn the extensive background knowledge, doctrine, tactics, and missions. Furthermore, much of the current funding is for building and fielding systems and not for research.

In this passage, they suggest that commercially available, interactive computer games would be a good source for use in AI development. One of the games that they mention (Starcraft) was actually used in our project, as well as many other games of the same genre. They are known as real-time strategy (RTS) games, because all players can manipulate their forces at the same time, and the animated entities respond to commands by acting immediately. RTS is actually somewhat of a misnomer, since most of these games focus on the tactical and/or operational levels of command and control, rather than the strategic level. The other type of game we examined is turn-based strategy, in which each player has as much time as they want between moves. Laird and van Lent also mention games that fall into categories not examined within this project, such as first person shooters (FPS), role playing games (RPG), and sports simulations. They then go on to emphasize the numerous benefits of using computer games for the purpose of AI research.

> In late 1997, we started to look for another application area, one where we could use what we learned from computer generated forces and pursue further research on human-level intelligence. We think we have found it in interactive computer games. The games we are talking about are not Chess, Checkers, Bridge, Othello, or Go, which emphasize only a few human capabilities such as search and decision making. The types of games we are talking about use the computer to create virtual worlds and characters for people to dynamically interact with - games such as Doom, Quake, Tomb Raider, Starcraft, Myth, Madden Football, Diablo, Everquest, and Asheron's Call.
>
> From the AI researcher perspective, the increasing realism in computer games makes them an attractive alternative to both robotics in the real world and home-grown simulations. By working in simulation, researchers interested in human-level AI can concentrate on cognitive capabilities and finesse many of the pesky issues of using real sensor and real motor systems - they must still include some sensor modeling to get realistic behavior, but they don't have to have a team of vision researchers on their staff. They can do this in worlds that are becoming increasingly realistic simulations of physical and social interactions, without having to create these worlds themselves. Computer games are cheap ($49.95), reliable, and sometimes surprisingly accessible, with built-in AI interfaces. Moreover, computer games avoid many of the criticisms often leveled against simulations. They are real products and real environments on their own that millions of humans vigorously interact with and become immersed in. Finally, unlike military simulations, we do not need to hunt out experts on these games; they surround us.

These passages give evidence of the importance of leveraging software developed by commercial game companies in the pursuit of improving AI in military simulations.

Laird and van Lent also mention the fact that there are numerous AI Ph.D.s currently working in the game industry, and many other researchers interested in using computer games as a topic of study for AI.

Methods, Assumptions and Procedures

This project required the purchase and evaluation of many commercially available computer wargames. The number of games purchased was limited by budget to fifteen; these games are listed in figure 1. These games were chosen by collecting information from various internet sources, including game review sites and the web site for the Air Force's Aerospace Basic Course, taught at Maxwell AFB, in Montgomery, AL. We also drew upon our own experience in the wargaming and computer gaming fields.

Title	Developer	Publisher	Genre	Price (as of 15 Feb 01)
Age of Empires 2: The Age of Kings	Ensemble Studios	Microsoft	RTS (real-time strategy)	$39.99
Civilization II	Microprose	Microprose	TBS (turn-based strategy)	19.99
Close Combat: Battle of the Bulge	Atomic Games	Strategic Simulations, Inc.	RTS	9.99
Command & Conquer: Tiberian Sun	Westwood Studios	Westwood Studios	RTS	19.99
Command & Conquer: Worldwide Warfare	Westwood Studios	Westwood Studios	RTS	19.99
Fleet Command	Jane's Combat Simulations	Jane's Combat Simulations	RTS	9.99
Force21	Red Storm Entertainment	Red Storm Entertainment	RTS	19.99
Homeworld	Relic Entertainment	Sierra Studios	RTS	29.99
M1 Tank Platoon II	Microprose	Microprose	RTS	19.99
Panzer General 3D Asssault	Strategic Simulations, Inc.	Strategic Simulations, Inc.	TBS	9.99
Pharaoh	Impressions Games	Sierra Studios	real-time city building	24.99
Star Wars Rebellion	Lucas Arts	Lucas Arts	RTS/TBS	24.99
Starcraft (Battlechest)	Blizzard Entertainment	Blizzard Entertainment	RTS	29.99
Total Annihilation: Kingdoms	Cavedog Entertainment	Cavedog Entertainment	RTS	9.99
Warcraft II (Battlechest)	Blizzard Entertainment	Blizzard Entertainment	RTS	19.99

Figure 1. A list of all wargames used in this project and other basic information about the games.

The three people who evaluated these games all used the same general guidelines for assessing them. The aspects of these games that we were most interested in were their graphics, sound, interface, AI and mutability (the amount of freedom the user was given to change things in the games). These last two criteria were the most important in terms of possible future uses for the games, for the following reasons. If any of the games had a highly intelligent and unpredictable AI, this could be beneficial for use in an Air Force

simulation. If a game were extremely flexible, to the point of being able to change the structure of the AI, it would be possible to leverage the game's graphics, sound and overall structure while improving the AI. This flexibility could also be used to change the graphics and/or sounds to reflect existing or future military units, structures and personnel.

Alternatively, if the games all lacked the necessary flexibility off the shelf, we thought it might be useful to approach the manufacturers to see if we could obtain the source code. Evaluations were written for each individual game, and then compiled for comparison and integration into this paper.

The following outline was created to assist the evaluators in their assessment of wargames. It was used as a guideline, but was not strictly adhered to.

1. Computer/Human Interface
   - a. Graphics
   - b. Sound
   - c. Input devices
     - i. Mouse
     - ii. Keyboard
     - iii. Other
   - d. Control Interface
     - i. Menus
     - ii. Maps
     - iii. On-screen "buttons"

2. Complexity
   - a. Different "Teams" (Countries, Races, etc.)
   - b. Number of Different Types of Units
   - c. Functionality of Individual Units
   - d. Functionality of Groups of Units
     - i. Of Same Type
     - ii. Of Many Types
   - e. Terrain Types
     - i. Air
     - ii. Land
     - iii. Sea
     - iv. Space
     - v. Other

3. Representation of the Elements of Combat
   - a. Air Power
   - b. Land Power
   - c. Sea Power
   - d. Close Fighting
   - e. Ranged Fighting

4. Artificial Intelligence
   - a. Individual Units
     - i. Moving
     - ii. Attacking
     - iii. Running Away
     - iv. Awareness of Friendly Units
   - b. The Computer Opponent Overall
     - i. Resource Management
     - ii. Building a Base (if applicable)
     - iii. Building up Forces
     - iv. Timing
     - v. Battle Strategies
     - vi. Battle Tactics

5. Mutability
   - a. Scenario/Map Editor
   - b. Other Scenario Building Tools
     - i. Voice Editing
     - ii. Unit/Character Editing
     - iii. Art Editing
     - iv. AI Editing
       - c. Code access

Results/Discussion

Figure 2 is a compilation of the results obtained by the evaluators, listing each game and its score in each of the five main categories listed in the evaluation criteria.

Title	Interface	Complexity	Forces	AI	Mutability	Total (of 32)
Age of Empires 2: The Age of Kings	8	3	3	6	6	26
Civilization II	4	4	4	6	6	24
Close Combat: Battle of the Bulge	6	3	2	2	2	14
Command & Conquer: Tiberian Sun	6	3	4	4	6	23
Command & Conquer: Worldwide Warfare	6	3	4	4	6	23
Fleet Command	8	3	3	4	4	22
Force21	6	3	3	4	2	18
Homeworld	8	3	2	6	2	21
M1 Tank Platoon II	6	3	3	6	2	20
Panzer General 3D Asssault	4	3	4	4	2	17
Pharaoh	8	4	1	4	2	19
Star Wars Rebellion	4	3	3	6	2	18
Starcraft (Battlechest)	8	4	4	6	6	28
Total Annihilation: Kingdoms	6	3	3	4	2	18
Warcraft II (Battlechest)	6	3	3	4	4	20

Figure 2. All of the games and their scores. The scale used for complexity and forces is 1-4; the other three categories have twice the weight (scored 2-8), as they are the main areas of interest in this effort.

Artificial intelligence was one of the foci of this project, since we were trying to determine whether or not improvements could be made to the games in this area. We found that many of the games needed improved AI; this is made clear in figure 2, as no game scored a perfect 8 for AI. The problem is that we did not have the opportunity to do anything about it. Making significant changes to the AI in commercial games is not possible without access to the source code. Some of the games we used had AI scripting features and "triggers" which allowed you to construct sequences of events within a scenario, but this does not touch the actual underlying AI system. Some of the games also gave an option allowing the user to change the difficulty level of the game, which may mean the AI level is increased, but this still does nothing to the structure of the AI. An

increase in difficulty level usually means that the units are given better statistics, such as improved vision, strength, and defenses. Our goal was to try to incorporate a non-rule-based AI into one or more of these games. This could be a neural network based AI, an AI based on evolutionary computation and/or genetic algorithms, or some other type of AI that has the capacity to learn. To do this, we would definitely need to have source code access. Unfortunately, this would be very costly to obtain.

After contacting the developers and/or publishers for these games, we received responses that indicated that a substantial fee would be required for the release of their source code, even if this was done under a non-disclosure agreement. One response requested $5k for their source code, while another requested $500k plus royalties. These figures were not in the range of this project's budget, eliminating this option. However, this was not the only option.

There are a few games available for download from the internet for free, with free source code. The majority of these games are written for the linux operating system. We did not have anyone proficient with the use of linux in our research team. There are a few games that have free source code (written in C) and can be compiled for Windows 95/98, but these games have very low-quality interfaces. One of the purposes of using COTS computerized wargames is to take advantage of their high quality graphics and intuitive user interface. Since the free games did not have either of these, it would not have been a good use of time to try and use them for this project. Another problem with trying to change an existing game so that it has improved AI, assuming that source code was available, is that code documentation would be necessary. Most of these games consist of hundreds of thousands of lines of code, which may be completely unreadable to the average programmer. Without documentation it is hopeless to try to make productive changes to the code, unless the programmer is willing and able to spend a very long time experimenting with it.

A better way to obtain a game that incorporates both the advanced graphics and interface of modern commercial games *and* an advanced, learning, unpredictable AI is to have game developers work with AI experts to develop a game/simulation from scratch. In this case, "from scratch" does not necessarily mean starting with nothing at all. The game developers may have large quantities of modular code that could be useful in creating such a program, while the AI experts may have written some code for another simulation that could be modified to fit into a computer wargame. The key is to get these people together and give them a reason to work towards this goal (usually this reason is money).

When the gaming industry begins to work with AI experts and military simulation experts on a regular basis, some amazing programs will surely come into being. We will learn to use computers' strengths to our own advantage instead of emphasizing their inability to emulate humans. For example, one common complaint about current AI is that the computer player cannot be as unpredictable as a human player; it is easy to figure out the rule set, and beat the game the same way every time. Game developers have realized this, and have compensated to make the game more challenging by giving the computer other advantages, like more units, more firepower, and the ability to do many things at

once. These abilities seem unfair to the human player, as it is not possible for a human to do as many things at the same time as the computer, and our reaction time is much slower. Instead of focusing on this as a weakness or a "cheat" against human opponents, why not exploit the fact that the computer can beat a human because of its faster reaction time and better multitasking capabilities? Combining these aspects with an unpredictable intelligence would likely create a computer opponent that no human could defeat. Although this would produce a commercially useless piece of software, it would be an invaluable resource in the real world, where in a global conflict potentially thousands of command and control decisions need to be made simultaneously.

There are undoubtedly countless improvements to be made to existing command and control simulation technology. Fusing the skills of commercial game developers and top-notch AI researchers will definitely be a step in the right direction. Not only will the resulting simulations provide decision support for our military commanders, but they are also likely to be marketable to the general public as entertainment! This might require a reduction in fidelity for security reasons, but the game quality would remain intact. We look forward to seeing the results of such an alliance.

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1. John E. Laird and Michael van Lent, *Human-level AI's Killer Application: Interactive Computer Games*, National Conference on Artificial Intelligence, AAAI Press, Austin TX, 2000.